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Assessing Trophic Status of Lake Guidimouni (Niger) Using Secchi Depth (SD) and Fish Communities

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Abstract
Determining the ecological conditions of lentic ecosystems using different parameters of the ecosystems is a relevant approache in water quality evaluating. The aim of this study was to examine the trophic state of lake Guidimouni according to Carlson system, OECD criteria and fish communities using data collected during 2 seasons. The Secchi depth values chanced from 0,95 m to 0,5 m respectively during the dry and wet season. Six (6) fish species belonging to 6 genera were identifed at lake Guidimouni. With regard to water quality, lake Guidimouni was eutrophic according to Carlson system during the 2 seasons, while it showed hypertrophic status according to OECD criteria. In accordance of fish communities, the lake Guidimouni showed a moderate ecological status. These results provide supplementary data about the lake's water quality and could help decision makers on the preservation of this important aquatic ecosystem.

Keywords: Secchi depth, fish communities, eutrophication, lake, Niger

1. Introduction
Water quality is determined according to the state which satisfies the aquatic organisms and human needs. The water status could be impacted naturally or through anthropogenic activities due to nutrient enrichment which leads to the development of microalgae. This condition is described eutrophication. The ecological state of lentics systems is an index of their biomass, definied as all of aquatic organisms supported within environmental conditions, especially phytoplankton [1]. During the last decades, inlandwater quality has impacted dramatically due to population growth, industrialization and climate variabilites, leading to severe water pollution and rarety worldwide [2, 3, 4, 5, 6, 7].
Assessing the ecological conditions of lentic systems using environnemental parameters of the systems is one of the recommended methods in water quality evaluating [8, 9, 10]. The characterization of ecological conditions based on the biomass of aquatic ecosystems is known as trophic states of the system which could served as water quality indicator [9].
Water clarity indicates the level of aquatic organisms activity and could be easily evaluated using a Secchi disk [11]. The measured value of a given sampling stations, which indicates the transparency of the water depens on to the level of dissolved solids in water, which in the end provides information about the quantity of living organisms.
Bio-monitoring freshwater quality becomes more interest in order to achieve sustainable environmental management, which maintains biological diversity. Fish populations are on of biological quality elements used in water quality assessment [12]. In fact, the diversity, abundance and age structure of fish population are considered as important ecological indicators of lakes. According to physicochemical and biological parameters four great trophic state of lakes and reservoirs including oligotrophic, eutrophic, mesotrophic and the hypertrophic state were considered. The present work aimed to determine the water status of lake Guidimouni based on water transparency and fish communities in order to contribute in the managment of this aquatic ecosystem.

2. Materıal and methods

2.1 Stady Area

The lake of Guidimouni is located in south-east of the district of Damagaram Takaya (basin of Zinder/Niger) with geographic coordinates 009°30',774 N and 13°41',577 E as shown in Figure 1. The lake plays a significant role in maintaining the biological diversity in the area. It runs along the RN1 (national road No. 1) for approximately 500 m on its right side. It covers an area of 338.39 ha and forms an elongated endorheic depression (SW-NE) nearly 3 km long and 700 m wide. The water body is formed by two large ponds whose average depth rarely exceeds 1.5 m [13]. Several socioeconomic activities including fishing, irrigation, livestock are developed around the lake.

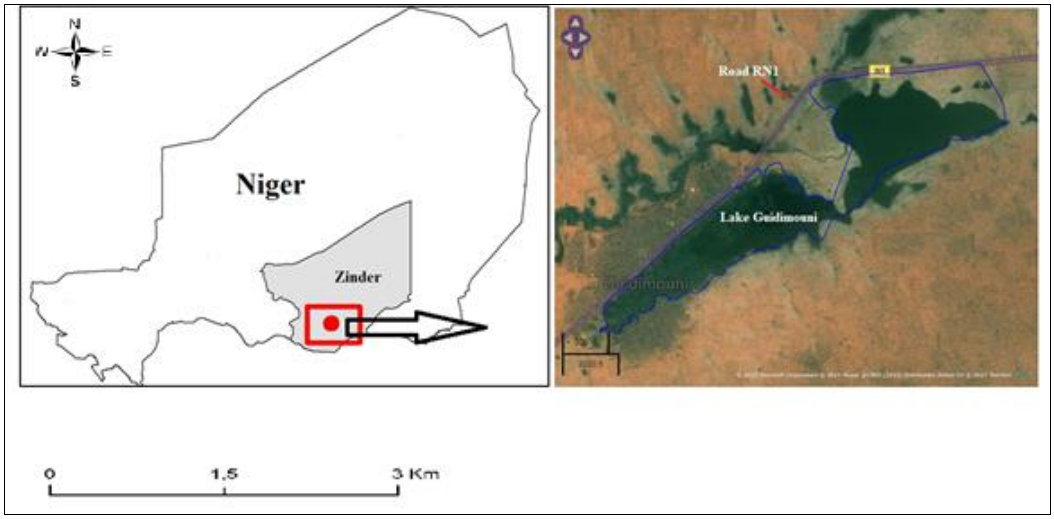

Fig 1: Localisation of the lake Guidimouni [13]

2.2 Data collection

Data were collected during the dry (March-April-May) and wet (August-september-october) seasons 2022. The Secchi depth was mesured using a Secchi disc one time in each mouth, while fish species were identified in situ using identification keys [14] from traditional fisher mens fishing. After the identification, fishes are counted, mesuded in order to characterize the lake fish population lac. Pour cela, trois (3) de sites de débarquement de pêcheurs ont été chois au bord du lac. This identification was supplemented by a list of fish species provided by local populations during a socio-professional survey.

2.3 Determination of Carlson's Trophic State Index (TSI)

The determination the trophic state index (TSI) [15] which consists to calculate an index using a scale of Secchi depth, is one of the appropriate methods recommended for the classification of lentic systems especially lakes and reservoir. This index could be obtained using the following formula (Eq.1).

$$TSI_{(SD)} = 10(6 - \ln[SD] / \ln[2]) \quad \text{(Eq. 1)}$$

The trophic scales of lentic systems according to trophic state index (TSI) is given in Table 1.

Table 1: Trophic scales for lentic systems according to TSI [15]

Trophic Classes	TSI
Oligotrophic	0–40
Mesotrophic	40–50
Eutrophic	50-70
Hypertrophic	>70

2.4 Classification according to OECD

The Organization for Economic Cooperation and Development (OECD) trophic classification [16] using Secchi depth was also applied to determine the trophic scales of the lake. The trophic scales lentic ecosystems according to this method are presented in Table 2.

Table 2: Trophic scales for lentic system according to OECD [16]

Trophic scales	Secchi depht (SD) (m)
Ultraoligotrophic	>12
Oligotrophic	12-6
Mesotrophic	6-3
Eutrophic	3-1.5
Hypertrophic	<1.5

2.5 Determination of water status using fish communities

The water status of the lake based on fish communities was evaluated accord to EU Water Framework Directive [12] as shown in the Table 3.

Table 3: Fish fauna and lake ecological status

Water Status	Diversity and biomass of fish poluations
High ecological status	High biomass and species diversity, occurrence of all age structures. This status indicates little sign of anthropogenic disturbance.
Good ecological status	Slight changes in species diversity and biomass, some age classes may be missing. This state indicate the degradation of environnemental coditions.
Moderate ecological status	The diversity of fish species and biomass change moderately according to the change in environnemental conditions resulted form anthropogenic activities.

2.6 Data Analyses

To test difference of the trophic status between the two season in the lake according to Carlson system and the OECD criteria, a one-way ANOVA) was applied at 95% confidence interval.

3. Results

3.1 Variation of the Seechi depth and the TSI values in the

lake

The measured Secchi depth (SD) and the determided TSI values are represented in the table 4. It appeared that highest Seechi depth value was found during the dry season, while the highest value of the calculated TSI was found during the wet season.

Table 4: Variation of the Seechi depth and the TSI values during the seasons

Parameters	Dry season	Wet season
Mean Secchi depth (m)	0,95	0,5
$TSI_{(SD)}$ (Carlon, 1977)	60,74	70

3.2 Trophic status of the lake according to the two (2) systems

The trophic status of the lake during the two seanson was hypertrophic and eutrophic respectively according to the OECD and the Carlon systems as shown in Table 5. The one-way ANOVA test applied between the two seasons showed a non-significant difference for each of the two (2) systems during the seasons (P> 0,05). However, a significant variation during the seasons between the two (2) methods ($p< 0.001$).

Table 5: Trophic state of the lake according to the OECD and Carlson systems

Classification systems	Dry season	Wet season
Secchi depth (m), (OECD)	Hypertrophic	Hypertrophic
$TSI_{(SD)}$ (Carlon)	Eutrophic	Eutrophic

3.2 Fish communities and water ecological status

To estemate the water ecolocal status of the lake based on fish community, the diversity and biomass of fish species and the age structure of the fish communities were studded.

The specific richness of ichthyologic fauna at lake Guidimouni including 3 orders divided into 5 families, 6 genera and 6 species is presented in table 6. Each family is represented by a single species except the cichlidae family with 2 species.

Table 6: List of fish species identified in the lac Guidimouni.

Order	Family	Scientific Name
Perciformes	Cichlidae	*Oreochromis niloticus* Linnaeus, 1759
		Tilapia zillii Gervais, 1848
	Latidae	*Lates niloticus* Linnaeus,1762
Siluriformes	Clariidae	*Clarias gariepinus* Bürchell, 1822
	Bagridae	*Bagrus bajad* Forsskal, 1775
Lepidosireniformes	Protopteridae	*Protopterus annectens* Owen, 1839

The surveys of fishermen revealed the disappearance of *Auchenoglanis occidentalis*, which was abundant in the lake.

Shannon diversity (H) and Pielou's evenness index (E) of the ichthyofauna for the two (2) seasons are presented in table 7. It appears from the analysis of this table that the Shannon diversity index and Pielou's evenness index varied depending on the season. The highest Shannon diversity index (H=0.86) and the lowest Pielou's evenness index (E=0.62) are obtained in the wet season, indicating the non-dominance of one species over the others as shown in Table 7. According to the one-way ANOVA result (p=0.204; p>0.05), there is no difference in the specific richness during the two seasons of the study period.

Table 7: Abundance and indices de diversité for the fish communities

Parameters	Dry season	Wet season
Especes number	5	6
Relative number	4672	7180
Shannon Diversity idex (H)	0,84	0,86
Pielou's evenness index (E)	0,76	0,62

The abundance between the different size classes of individuals is unevenly distributed. This distribution represents the age structure of fish communities as shown in Figure 2 in the lake. Indeed, the size classes [3-6[and [6-9[had the greatest number of individuals while the least represented classes are respectively [24-27] and [18-21].

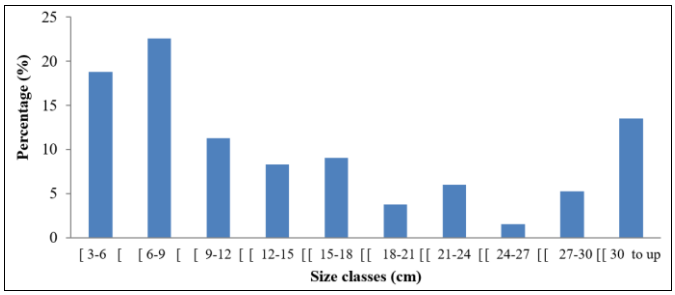

Fig 2: Age structure of fish species in the lake according to size classes during the study

The result showed that the majority of individuals (70%) are young and sub-adults with a size compris between 6 and 15 cm. Adult individuals larger than 15 cm are rare, especially for Cichlidae family, particularly *T. zillii*. Those that exceed 21 cm are generally *P annectens*, *L. niloticus* and *C. gariepinus*. In accordance of this result, the lake Guidimouni showed a moderate ecological status.

4. Dıscussıons

The lake Guidimouni showed different trophic states according to the two (2) approaches, but showed the same trophic status using each of the two systems during the two seasons. One trophic category (eutrophic) based on TSI and one trophic state (hypertrophic) according to the OECD criteria were recorded. Compartive trophic classes using the same systems were reported in Turkey [17], and in Itay [18]. These trophic states have also been indicated in Spain [19, 20], at Lakes Sumin and Másluchowskie in Eastern Poland [21], at Pareja limno-Reservoir (Spain) [22], at Alleben Reservoir (Turkey) [6], and in France [23]. Eutrophic and hypertrophic status from several lakes in Turkey [24]. But, lentics ecosystems could indicated different trophic scales according to the employed classification systems [25, 26].

The trophic classes observed at the lake could be due to human impacts. In fact, it has been reported that tomatoes, corns, watermelons, jaxatine, cabbages, onions, potatoes, peppers, carrots, banana and others are are cultivated in the area [13]. During these activities, farmer often use pesticides, mineral fertilizers and others products to improve the development of crops. Agriculture and others human activities are among the main pollution sources of aquatic ecosystems [17, 27, 28]. An inventory carried out on the use of pesticides around the lake Guidimouni indicated that farmers use pesticides and others chemical products that can lead to the degradation water quality [29].

The lake showed a moderate ecological status based on fish communities. In fact, it appears from the result low diversity

and individual numbers of the fish population. The majority of individuals (70%) are young and sub-adults. In accordance of this result, the lake Guidimouni showed a moderate ecological status [29]. This state could be explained by the deterioration of the environnemental characteristic of the water body due to human activities including the usage of pestides, overfishing and the introduction of carnivorous species such as the Nile crocodile (*Crocodylus niloticus*) and the *Lates niloticus*.

5. Conclusion

The trophic status of lake Guidimouni was determined using the Carlson and the OECD proposed methods. Highest Seechi depth value was found during the dry season, while the highest value of the calculated TSI was found during the wet season. The age structure of fish communities showed that the majority of individuals (70%) are young and sub-adults with a size compris between 6 and 15 cm. Adult individuals larger than 15 cm are rare, especially for Cichlidae family, particularly *T. zillii*. Those that exceed 21 cm are generally *P. annectens*, *L. niloticus* and *C. gariepinus*. With regard to water quality, lake Guidimouni was eutrophic according to Secchi depth based on Carlson system during the 2 seasons, while it showed hypertrophic status according to OECD criteria based on Secchi depth. In accordance of fish communities, the lake Guidimouni showed a moderate ecological status. From these, it appeared that the Carlson systeme and the OECD criteria could be used to evaluate the trophic state of sahelian lentic systems.

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